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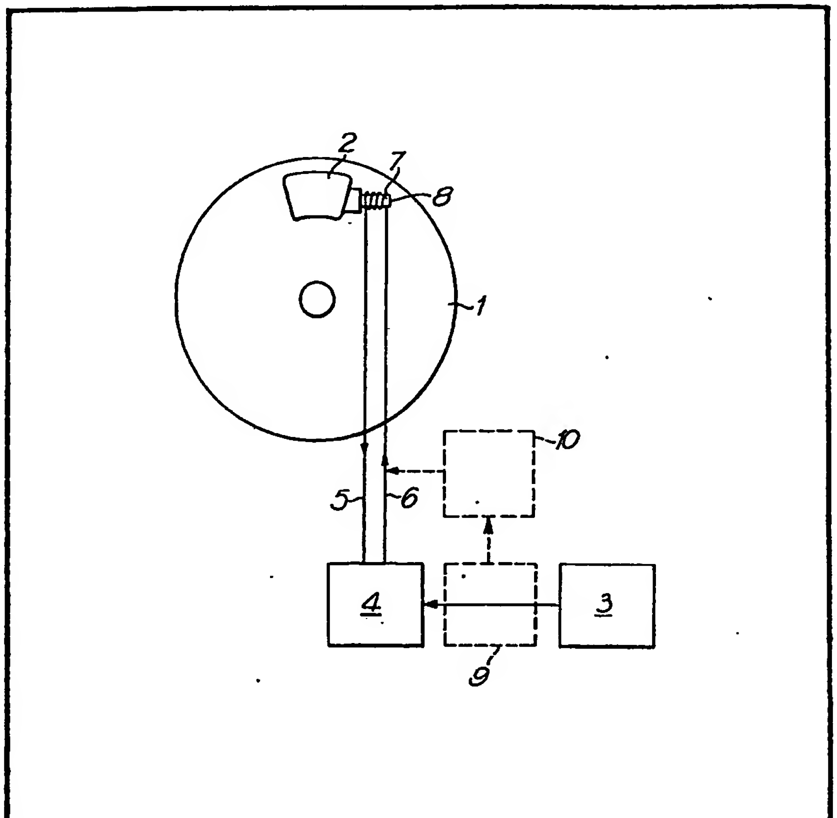
(54) Applying Ultrasonic Vibration to Friction Member

(57) The invention is concerned with the rapid release of frictional force which is acting to reduce relative movement between contacting surfaces, the normal actuating means being unaffected. One application is in an anti-lock braking system in vehicles, particularly motor-cycles. A sensor 3 monitors wheel angular velocity and when this falls below a predetermined value the sensor causes ultrasonic vibrations to be applied to brake pads 2 effectively reducing friction without release of brake operating pressure to enable resumption of normal rotation. A short duration dc pulse of appreciable magnitude may be applied to the transducer at the onset of the normal input signal to produce a short duration surge to rapidly break the frictional force between the friction member and the moveable member to enhance speed of release. The transducer may also be applied directly to the end wall of a friction member hydraulic operating cylinder when ultrasonic vibrations will be transmitted through the operating fluid to the piston connected to the friction member. The end wall of the cylinder is of a suitable matching material to facilitate transmission of the ultrasonic energy and the piston is formed so as to minimise attenuation.

The invention can also be applied to friction clutches operating in either rotary or linear senses to cause release when overloading or overspeed occurs or to give gradual engagement in accordance with a predetermined programme.



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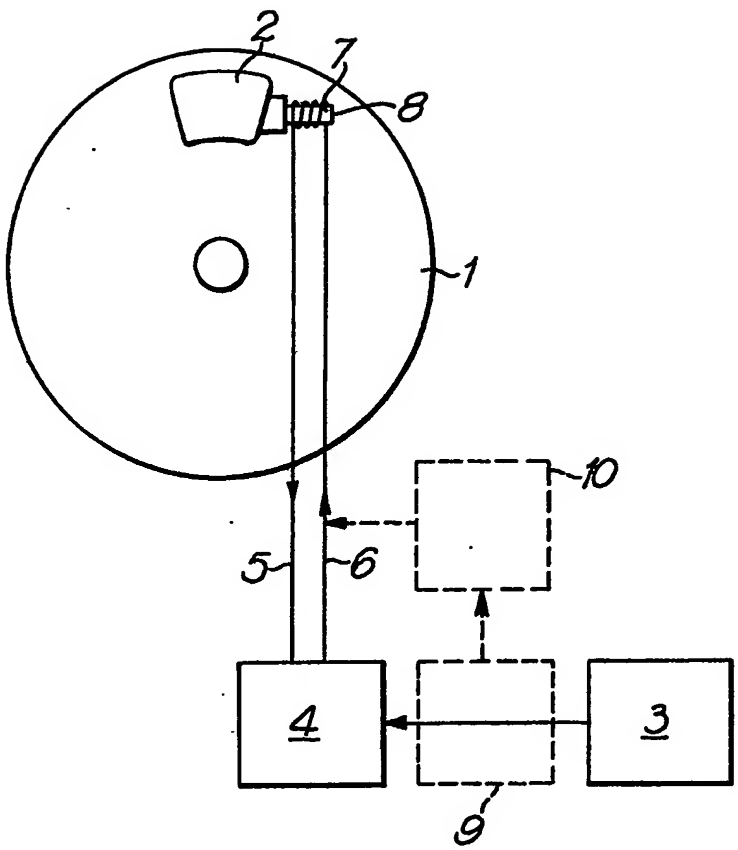

SPECIFICATION
Friction Controllers

The invention relates to friction controllers whereby frictional forces in brakes, clutches and the like may be varied independently of the normal operating mechanism.

The invention can advantageously be applied to vehicle braking systems, especially in motor-cycles, as an anti-lock device, and as a slipping clutch in mechanisms transmitting power or control movements, for example winches on cranes etc, but is not limited to these functions.

The invention provides a means of reducing frictional forces in controlled manner by utilising the known effect of the application of ultrasonic vibration.

In wheeled vehicles, the application of brakes tends to wheel locking especially in wet or otherwise slippery conditions leading to skidding which can cause flats on the wheels of rail vehicles and loss of directional control in other cases coupled with reduction in braking effort. Wheel locking whilst always undesirable is particularly serious in the case of motor-cycles. A recent survey has shown that motor-cycles (including scooters and mopeds) account for only about 2% of the total road vehicle mileage in Britain but produce 14% of casualties in accidents, many of which occur because braking is inadequate or incorrectly applied in prevailing conditions.

Anti-lock braking systems are well known and usually comprise a sensor for detecting excessive deceleration in a wheel and which is connected to release the applied brake pressure until the wheel recovers a predetermined rate of rotation, when braking is reapplied; the sequence being repeated until the wheel comes to rest or the brakes are released normally.

Such systems are in practice usually limited to brakes applied hydraulically or pneumatically since they are difficult to adapt to mechanically applied brakes.

A friction controller assembly according to the invention includes a movable member, a friction member arranged to engage the movable member and a sensor connected to apply ultrasonic vibration to at least one of the members.

In one embodiment, the movable member is a disc connected to a wheel, the friction member is a brake pad and the sensor is arranged to monitor the angular velocity of the wheel on brake application and to apply ultrasonic vibrations to the brake pad when the angular velocity falls below a predetermined value.

In another embodiment, the movable and friction members are coaching clutch elements.

Various embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawing which shows part of the braking system of a vehicle.

The braking system includes a metal disc 1 connected to a wheel (not shown) so as to rotate with it. A pair of brake pads 2 (one only shown), of a material having a high coefficient of friction, on either side of the disc, are connected by a caliper mechanism (not shown) whereby the pads may be urged into contact with the disc by a suitable actuating arrangement so as to apply a braking force. The actuating arrangement may be of any suitable conventional kind including the use of hydraulic, pneumatic or mechanical pressure.

A sensor 3 is connected to an ultrasonic generator 4 which is connected in turn by wires 5, 6 to the coil 7 of a magnetostrictive transducer 8 which is in contact with one of the brake pads 2. Alternatively there may be two magnetostrictive transducers, one in contact with each brake pad.

The sensor 3 is arranged to monitor the angular velocity of the vehicle wheel either directly through the medium of the disc 1 during brake application. Thereafter if the wheel decelerates at a rate greater than a predetermined setting (usually 1 g) the sensor applies a signal to the ultrasonic generator 4 which energises the coil 7 thus exciting the magnetostrictive transducer(s) whereby an ultrasonic vibration is applied to the brake pad or pads 2. This has the known effect of reducing the frictional force between the pad or pads and the disc 1 whereby the wheel recovers velocity at which points the sensor 3 ceases to apply the signal to the ultrasonic generator 4 and normal brake force is reapplied. This sequence of operations continues repetitively whenever there is a tendency to wheel locking until the vehicle either stops or brakes are released.

By this means the braking force applied by the pad or pads 2 is maintained to the maximum degree possible. This can be especially important during "emergency" situations when a road surface is wet and slippery, and optimum control, particularly of a motor-cycle, can be maintained.

Since the system is independent of the normal brake actuating means and has no moving parts, there is a minimum time lag in its operation which is more rapid than that which might be reasonably expected where the brake actuating means are intermittently applied and released.

Various modifications consistent with the state of the art may be applied to the arrangement described. For instance the sensor 3 might include an accelerometer to measure the rate of retardation of a vehicle, the brake pads may be applied directly to a wheel eg at the rim, or conventional drum brakes may be used, while the magnetostrictive transducer may be replaced by one of the piezo-electric type which is an alternative device for converting electrical oscillation to mechanical. Ultrasonic vibrations may also be applied to the disc 1.

The displacement caused by the magnetostrictive or piezo-electric transducer may be applied to the appropriate friction member in any desired direction. In the foregoing embodiment, this is applied in the plane of rotation and along the line of instantaneous

direction of rotation which is believed to be most suitable for that particular application, but any other direction either in the plane of rotation or out of it might be more advantageous according to the prevailing circumstances.

It is known in ultrasonic transducers, particularly of the piezo-electric type, to apply a dc bias to the oscillatory input signal in order to provide more definite response.

In a modification to the foregoing construction, a short duration dc pulse of greater magnitude than the normal dc bias is applied at the onset of the input signal.

Referring again to the drawing, a function generator 9 (shown dotted) is interposed between the sensor 3 and the ultrasonic generator 4 and has an additional output which passes by way of a dc pulser 10 (dotted) to the output connection 6 from the ultrasonic generator to the transducer 8. The function generator comprises a starter and dc pulse timer whereby the onset of a signal from the sensor causes a dc pulse of duration equal to one or two cycles at an operating frequency of $\simeq$ 20 KHz to be fed to the transducer 8 effectively simultaneously with the output from the ultrasonic generator 4. This produces a surge which will rapidly break any friction bond likely to exist between the friction member and the movable member without the need for build up of normal oscillations. This will give more rapid reduction of the frictional force than would normally be possible otherwise and thus a greater degree of control. An incidental advantage is that less power will be needed overall since the amplitude of the ultrasonic vibration can be less than if it were required to break the frictional bond unaided. The effect of the dc pulse is probably more pronounced in the case of a piezo-electric transducer where it will act to compress the crystal very rapidly but similar results have been achieved using a magnetostrictive transducer. It has also been found advantageous in this context for the displacement caused by the transducer to be applied radially to the friction member with respect to a rotating movable member.

In a further modification to the basic construction wherein hydraulic means is employed to actuate the friction member, a transducer is applied directly to the closed end of the actuating cylinder and the ultrasonic vibrations emanating from the transducer are transmitted through the operating fluid to the piston which may conveniently carry the friction member. The end wall of the cylinder is of a suitable matching material eg stainless steel which will facilitate transmission of ultrasonic energy and the piston is appropriately formed according to its own characteristics and those of the operating fluid so as to minimise any attenuation of ultrasonic energy at the piston/fluid interface.

In another embodiment, the invention is applied to friction clutches, which may operate in either angular or linear senses, and the sensor arranged to detect other undesirable conditions such as overloading eg by strain gauge, or overspeed whereby the application of ultrasonic vibrations to one of the clutch elements allows the clutch to slip during such time as the adverse conditions are maintained.

Very precise control of a clutch is obtainable by the use of a function generator interposed between a sensor and ultrasonic generator whereby the input to the ultrasonic generator may be varied to give gradual engagement thus:

a. partial engagement to provide slip;

b. partial engagement prior to full engagement to lesson shock loading of driving unit and/or transmission;

c. movement towards full engagement in a pre-programmed manner, ie to engage in accordance with a linear or non-linear function maintaining the speed of a driven load within specified limits might best be achieved using a conventional closed loop control system but it can be advantageous to allow the clutch to slip whilst varying the speed of the driving means.

The sensor can be arranged to detect any appropriate signals, analogue or digital, representing torque, temperature or other measurable predictable parameter.

Claims

1. A friction controller assembly including a movable member, a friction member arranged to engage the movable member and a sensor connected to apply ultrasonic vibration to at least one of the members.

2. A friction controller assembly according to claim 1 comprising a rotatable disc member, a pad of high friction material arranged selectively to contact the disc member and a transducer disposed so as to apply ultrasonic vibration to the pad in response to sensor output.

3. A friction controller assembly according to claim 2 in which the disc member is connected to a wheel and the sensor is adapted to monitor the angular velocity of the wheel.

4. A friction controller assembly according to claim 2 or claim 3 in which the transducer is of magnetostrictive type.

5. A friction controller assembly according to claim 2 or claim 3 in which the transducer is of piezo-electric type.

6. A friction controller assembly according to any of claims 2 to 5 having an ultrasonic generator and another function generator in circuit between the sensor and the transducer.

7. A friction controller according to claim 6 in which the function generator acts to vary the input to the ultrasonic generator.

8. A friction controller according to claim 6 in which the function generator has an additional output connected by way of a dc pulser to the transducer.

9. A friction controller assembly according to any of claims 2 to 8 in which the pad is urged into contact with the disc by hydraulic means and the ultrasonic vibration is transmitted to the pad through the agency of hydraulic fluid.

10. A friction controller assembly according to any of claims 2 to 9 in which the pad is mounted on a piston operating in a hydraulic cylinder and the transducer applies ultrasonic vibration to hydraulic fluid in the cylinder.

11. A vehicle braking system including a friction controller assembly according to any previous claim.

12. A vehicle braking system comprising a wheel and a pad arranged to apply frictional force to the wheel in which ultrasonic vibration can be applied automatically to the pad when the angular velocity of the wheel falls below a predetermined value.

13. A vehicle braking system according to claim 12 comprising a disc connected to rotate with the wheel, a pad connected to be urged into contact with the disc and a transducer disposed to apply ultrasonic vibration to the pad in response to output from a sensor arranged to monitor angular velocity of the wheel.

14. A vehicle braking system according to claim 13 further comprising a hydraulic actuator in which the pad is mounted on a piston and the transducer applies ultrasonic vibration to the end wall of a cylinder in which the piston operates.

15. A vehicle braking system according to claim 14 in which the end wall is of a material which will facilitate transmission of ultrasonic energy.

16. A vehicle braking system according to claim 15 in which the end wall is of stainless steel.

17. A vehicle braking system according to claim 14, claim 15 or claim 16 in which the piston is formed to minimise attenuation of ultrasonic energy.

18. A vehicle braking system according to any of claims 12 to 17 in which means are provided to feed a dc pulse to the transducer at the onset of a signal from the sensor.

19. A vehicle braking system according to claim 18 including a starter operable by signal from the sensor and a pulse generator.

20. A friction clutch comprising a friction controller assembly according to any of claims 1 to 10.

21. A friction clutch including a movable member, a friction member arranged to engage the movable member, a sensor connected to apply ultrasonic vibration to at least one of the members and a function generator to vary the ultrasonic vibrations whereby clutch engagement may be modified.

22. A friction controller substantially as herein described with reference to the accompanying drawing.

23. A vehicle braking system substantially as herein described with reference to the accompanying drawing.

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